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Portable emergency telemedicine system over wireless broadband and 3G networks

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Abstract—**The telemedicine system aims at monitoring patients remotely without limit in time and space. However the existing telemedicine systems exchange medical information simply in a specified location. Due to increasing speed in processing data and expanding bandwidth of wireless networks, it is possible to perform telemedicine services on personal digital assistants (PDA). In this paper, a telemedicine system on PDA was developed using wideband mobile networks such as Wi-Fi, HSDPA, and WiBro for high speed bandwidths. This system enables to utilize and exchange variety and reliable patient information of video, biosignals, chatting messages, and triage data. By measuring bandwidths of individual data of the system over wireless networks, and evaluating the performance of this system using PDA, we demonstrated the feasibility of the designed portable emergency telemedicine system.**

I. INTRODUCTION

Recent developments in telecommunications and information technology enhanced availability of telemedicine system in health care fields[1]. Telemedicine is defined as the delivery and sharing of medical information of patient over a distance using telecommunication means [2]. Existing telemedicine systems only exchange the information in a limited location. Using the portable device, the telemedicine service is feasible on the move.

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A personal digital assistant (PDA) is a handheld computing device enabling the doctor to monitor his/her patients remotely [3]. Recently, PDAs have the size of the palm of the hand and provide the faster processing speed and high speed wireless networks.

In this paper, a portable emergency telemedicine system was developed using PDAs with these advantages. This system enables to utilize and exchange variety and reliable patient information of video, biosignals, chatting messages, and triage on PDAs, which provide wideband mobile networks as Wi-Fi, HSDPA, and WiBro. This paper also measured bandwidths of individual data over wireless networks and considered an appropriate network for this portable emergency telemedicine system.

II. MATERIAL AND METHODS

A. System configuration

A portable emergency telemedicine system over wireless broadband and 3G networks is shown in Fig.1. A camera and a patient monitor which are connected to UMPC (Ultra Mobile Personal Computer) acquires video and biosignals of a patient. Those video and biosignals are transferred in real-time to a PDA of a doctor with wireless network. The patient monitor is connected to the UMPC using Bluetooth. The patient monitor is the system which was developed for the portable telemedicine system.

Images and data of the patient are transferred to the PDA of the doctor using a file-transfer module, if necessary. A chatting module could be used for exchanging messages between the patient and the doctor. The doctor can also transfer a triage of an emergency patient to the UMPC on the patient side.

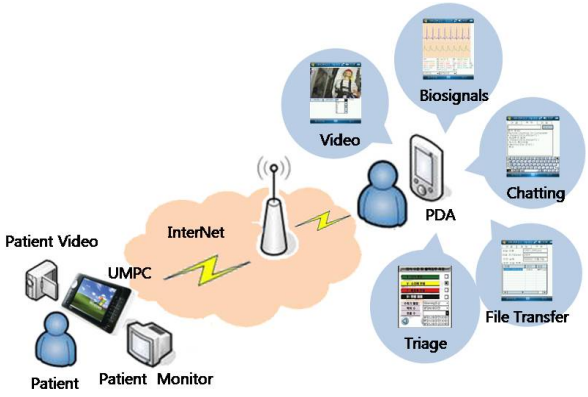

Fig. 1 Overall system architecture

B. Development Environment

ActiveSync and Windows Mobile 5, 6 SDK were used to design the PDA application. Devices based on Windows Mobile 5, 6 platforms on Microsoft's Windows CE were used. The application was developed using C++, MFC.

C. Network

Wi-Fi, HSDPA and WiBro, which are wireless networks, were used for communication between doctor and patient. Table 1 shows the frequency bands and transmission speeds of Wi-Fi, HSDPA, and WiBro. Wi-Fi is wireless network technology connected to access points (AP) in the 2.4 GHz band. HSDPA (High Speed Downlink Packet Access) achieves high data rates and high spectral efficiency by using adaptive modulation and coding schemes, and employs multi code CDMA [4]. Wibro (Wireless Broadband), developed by South Korea, is a wireless broadband internet technology enabling access to internet on the move [5].

TABLE I
FREQUENCY BAND AND TRANSMISSION SPEED BY WIRELESS NETWORKS

	Wi-Fi	HSDPA	WiBro
Frequency Band	2.4GHz	2.1GHz	2.3GHz
Transmission Speed(upload)	11Mbps	1Mbps	3Mbps

D. System Evaluation

We performed an experiment on efficiency of the portable emergency telemedicine system over wireless networks. Wibro and HSDPA were used for mobility. The experiment was carried out using the same wireless networks between the sending and receiving sides. We measured the individual bandwidths of video, biosignals, images, triage of patient and chatting.

III. RESULTS

A. Socket Communications

The data communications for telemedicine require sockets, which connect data to networks. When telemedicine is commenced, sockets are created separately and this initiates data transmission of video, biosignals, file transfer, chatting, and triage and data communications.

B. Video

Data flow and user interface of video module on PDA are shown in Fig. 2. On PDA, the video module displays video data of a patient that the UMPC transfers in real time enabling the doctor to monitor his/her patients remotely. The video data was compressed highly using 'Xvid', which was a video codec library following the MPEG-4 standard and transferred to PDA of a doctor. A transform filter of Directshow for windows mobile platform was developed and the video is displayed on PDA using source filter and render filter.

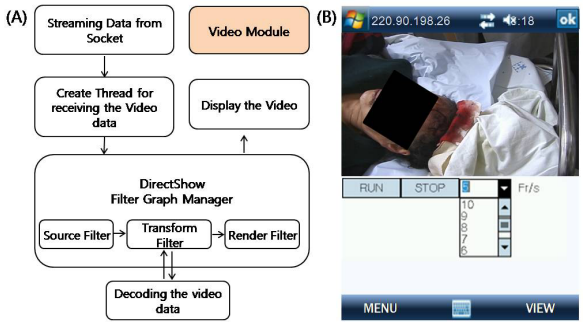

Fig. 2 (A) Data Flow of Video (B) User Interface of Video

C. Bio-Signals

Data flow and user interface of patient biosignal module are shown in Fig. 3. Like video, patient biosignal is an essential element to diagnose patients. ECG, SpO2, Respiration, NIBP, and temperature acquired from monitoring a patient were transferred to PDA and the biosignal module displays those biosignals in real time on PDA. In order to gain further accurate ECG signals, an additional function was developed of extending signals, displaying and storing the file via utilizing ECG dialog.

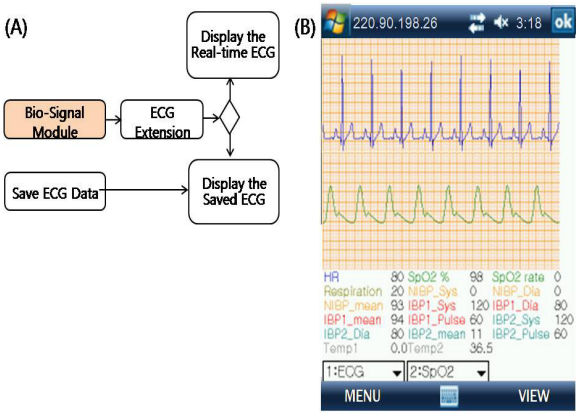

Fig. 3 (A) Data flow of Biosignal
(B) User interface of Biosignal module

D. File Transfer & Chatting

Data flow (A) and user interface (B) of file transfer & chatting are shown in Fig. 4. The file transfer module receives images or documents of a patient from transfer and displays on PDA. The chatting module enables communication between patient and doctor. Thanks to the small data size required for exchanging chatting messages, it could send and receive messages easily regardless of networks. The data type of PDA is different from that of desktop, thus requiring type transform.

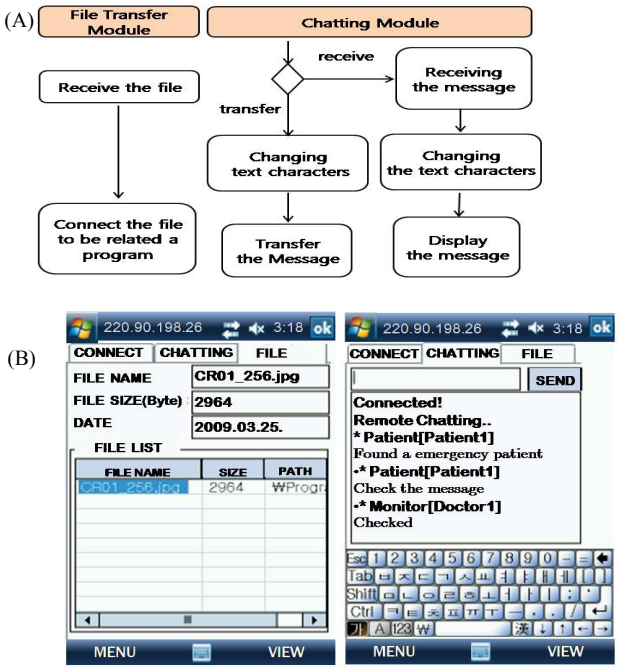

Fig. 4 (A) Data flow of File Transfer & Chatting
(B) User Interface of File Transfer & Chatting modules

E. Triage

Data flow (A) and user interface of triage module shown in Fig. 5. The triage module performs triage to expeditiously define the casualties' condition [6] and transfers data to a remote PDA of a doctor, displaying triage contents using chatting module on PDA. To triage emergency patients, the Triage Score by remodeling the R.T.S (Revised Trauma Score) was used [7].

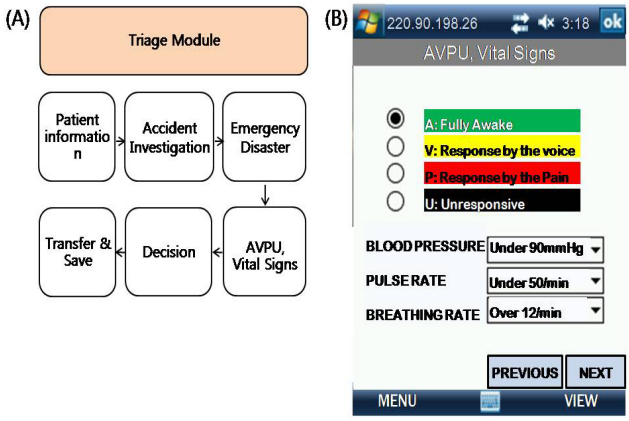

Fig. 5 (A) Data Flow of Triage
(B) User Interface of triage module

F. Evaluation

Fig. 6 shows video data bandwidth per second, which was measured when the patient side transferred the video data over WiBro or HSDPA. The measured bandwidth was 100Kbps~300Kbps over HSDPA and 500Kbps~1000Kbps over WiBro. The official bandwidth provided was approximately 1Mbps over HSDPA and was around 3Mbps over WiBro. As a result, it was possible to service video in real time on PDA. The average bandwidth of biosignal was 11.7Kbps, an extremely small bandwidth compared to patient video data, thus not influencing the bandwidth test much. The file data aims at transmitting still video cuts, therefore the maximum resolution does not go over 320 × 240. Also, as it is a still cut, it did not affect the test.

The transmitted video quality was compared to judge whether the video was successfully sent and received or not. The quality between the non-compressed original video and the transmitted video were compared using PSNR. The test using WiBro measured to have an average 33.7dB PSNR based on a 320 × 240 resolution and 15 frames/s rate Xvid codec. Such discrepancy of video quality is minimal, as more than 30dB difference is needed to seem different in the human eye [8], [9].

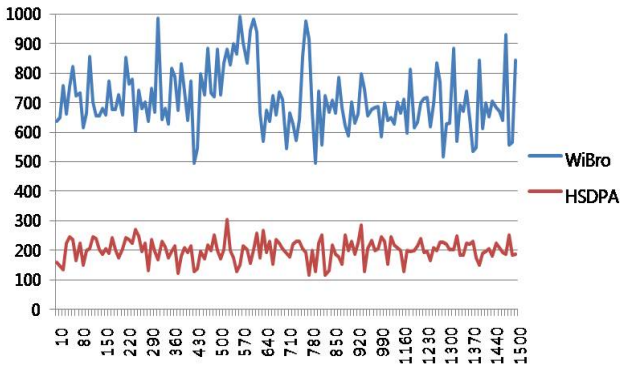

Fig. 6 Video Data Bandwidth per Second

IV. DISCUSSION & CONCLUSION

In this paper, a portable emergency telemedicine system on PDA was developed over wireless networks. Medical services of video, patient biosignals, sending images and documents, exchanging messages, and triage were offered. High speed wireless networks such as Wi-Fi, HSDPA, and WiBro were used for seamlessly sending medical data. The transmission bandwidths of individual modules were measured to certify the efficiency and stability of this system. The quality of the original video and the transmitted video were compared using PSNR.

The bandwidths of 300Kbps over HSDPA and 1000Kbps over WiBro were measured. As a result, it was possible to service video in real time on PDA through high speed wireless networks. However, video transmission was delayed by little when processing data based on 320 × 240 resolution and over 12 frames/s rate. That was also delayed with biosignals in case of 6 frames/s rate.

In this paper, a portable emergency telemedicine system was developed. Compared to existing telemedicine systems, this system was feasible on utilizing and exchanging variety and reliable patient information, thus enabling the doctor to monitor his/her patients remotely. By adjusting the frame rate in real time over wireless networks with variable

transmission speed, it was also possible to diagnose efficiently.

To more comfortable and speedier telemedicine, future research will address the portable telemedicine system added a voice function between patient and doctor.

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